

Mekong River Delta farm-household willingness to pay for salinity intrusion risk reduction

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ABSTRACT

Sea level rise and upstream development is causing salinity intrusion in Vietnam's Mekong River Delta (MRD) and, as a consequence, agricultural productivity is declining. As the Vietnamese government and local communities search for a solution, it has become apparent that there are insufficient public resources to build the dykes necessary to control this problem. So, we employ a referendum contingent valuation methodology (CVM) to determine whether or not farm households might be willing to pay for part of the cost of a salinity intrusion risk reduction program. We find that farm households are willing to contribute funds to such a program. In areas where salinity intrusion is already reducing productivity, farm households are willing to contribute US\$2.58 per month. In areas where salinity intrusion is expected to be reducing productivity by 2030, willingness to contribute is US\$1.99 per month. Surprisingly, in MRD areas where salinity intrusion is not expected within the next 15 years, willingness to contribute remains positive at US\$1.32 per month. These findings have local, national and international implications that require careful consideration. In passing, we make a methodological observation that a treatment model including 'do not know' responses provides consistent results with conventional referendum elicitation procedures.

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1. Introduction

The Mekong River Delta (MRD), located in southern Vietnam, plays an important role in the country's agricultural development. The total agricultural area is four million hectares, producing approximately 45% of Vietnam's rice. While salinity intrusion impacts are beginning to affect other river deltas around the world, if mean sea levels rise by one meter above current levels, Vietnam would be the most adversely-affected region in the developing world (Buys et al., 2006).

In the past, flooding was the most typical cause of disruption to agricultural production in this region (Le Anh Tuan et al., 2007). In recent years, however, salinity intrusion has become the most significant challenge faced by farm households. Salinity intrusion is caused by two processes: a) rising sea levels as a result of adverse climate change and b) a significant decline in river flows as a result of upstream dam construction and increased extractions of water. Reduced upstream flow rates combined with increased sea lev-

els under climate change drive lower hydrologic pressure in the MRD, which allows salt water to intrude further inland (Danh and Khai, 2014; Le Anh Tuan et al., 2007; Smajgl et al., 2015). According to the Vietnam Academy for Water Resources, salinity intrusion is on the increase and has recently been detected in the Kien Giang and Hau Giang provinces (see Fig. 1) (The Vietnam Academy for Water Resources, 2015). Currently, around 620,000 ha are affected by salinity intrusion—roughly 16% of the total MRD agricultural production area. By 2030 under current sea level increase predictions, it is estimated that up to 45% of the MRD agricultural area could be impacted, with coastal provinces such as Tien Giang, Tra Vinh, Soc Trang, Bac Lieu, Ca Mau, and Ben Tre experiencing the highest levels of impact (Center of Environmental Engineering, 2012).

Adverse impacts of sea level rise are being worsened by increasing upstream development along the Mekong River. The National Hydro-Meteorological Service of Vietnam is warning that the impact of future droughts, similar to those experienced during the 2015 and 2016 El Niño events, will also be worse in future, creating further negative salinity intrusion outcomes.

As one of the largest rice exporters in Asia, disruptions to MRD agricultural production can result in wider serious regional food security issues, as well as reduced national trade income. In the past, MRD farm households largely treated salinity intru-

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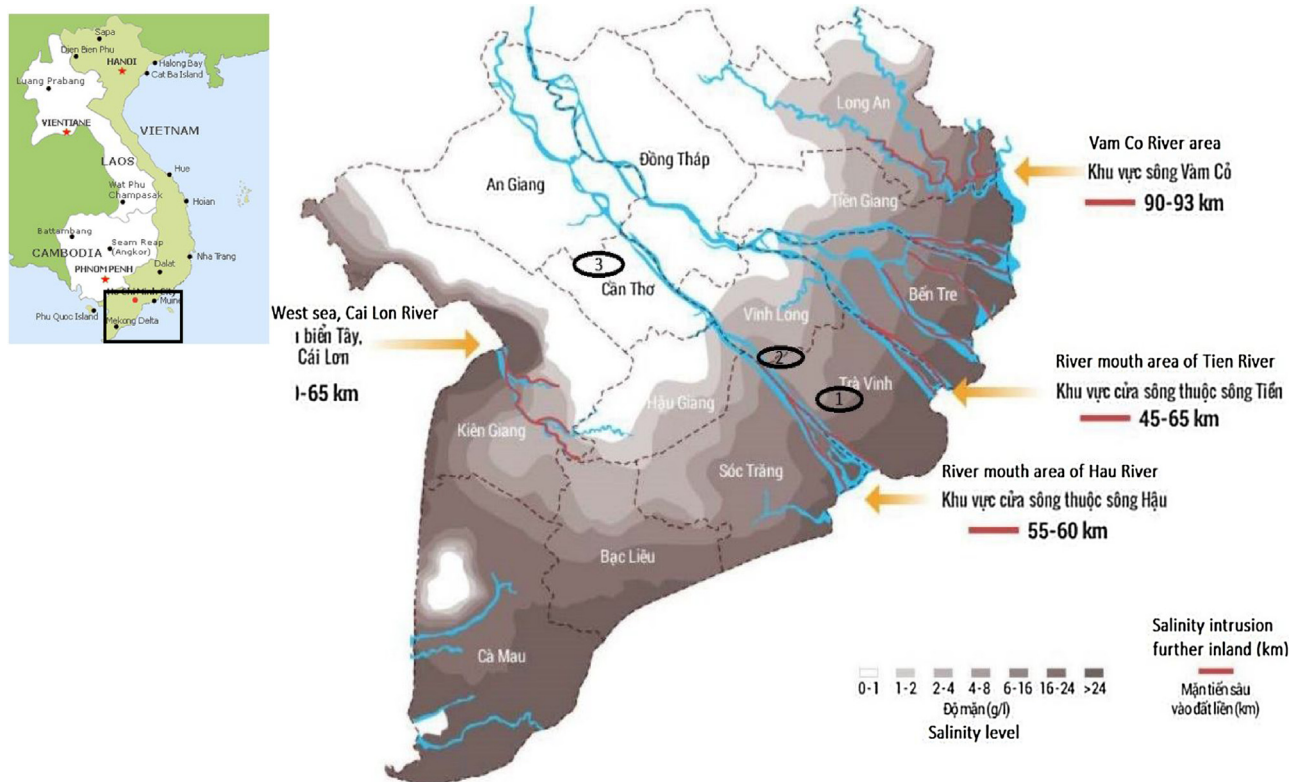


Fig. 1. MRD salinity intrusion, 2015. Study area locations are also indicated: 1) Cau Ke district, 2) Cau Ke and Tra On districts, and 3) Vinh Thanh district.

Source: Adapted from [The Vietnam Academy for Water Resources \(2015\)](#)

sion as a normal phenomenon ([Le Anh Tuan et al., 2007](#)). More recently, under increasing salinity impacts, farm households and local authorities have recognized the abnormal properties of local salinity intrusion, and begun searching for management solutions including changed irrigation schedules, increased water storage in dams, and altered rice-planting times. These solutions are largely viewed as short-term (1–5 year duration) fixes. However, under a recent recognition that increasing salinity intrusion cannot be managed by private on-farm actions alone, in 2016 the General Program of the Mekong Delta Economic Cooperation Forum in Hau Giang (MDEC Forum - Hau Giang) argued that it would be necessary to explore and develop longer-term (5–30 year) solutions based on public intervention.

One possible long-term approach is the use of concrete sea-dikes or embankment-structures that prevent water inundation onto low-lying floodplain areas. The MRD is a vast floodplain only 0–4 m above mean sea level. Over the last 300 years, more than 11,000 kilometers of canals have been constructed in the MRD to mitigate flooding in low-lying areas. In addition, approximately 2000 kilometers of dike walls have been constructed to minimize MRD flooding during periods of high upstream flows and very high tides that can occur during storm events ([Le Anh Tuan et al., 2007](#)). In May 2009 the Vietnamese government issued Decree No. 667/QĐ-TTg with a view to upgrading dike walls and increasing maintenance in the central and southern MRD. This program will include the construction of additional earthen sea-dikes and concrete sluiceways along the coastline ([Danh and Khai, 2014](#); [Smajgl et al., 2015](#)). As there is a shortage of soils suitable for upgrading these dikes, and the incidence of erosion is high ([Sorensen et al., 1984](#)), consideration is being given to the construction of concrete sea-dike-walls.

According to a UNDP Disaster Management Unit Project (VIE/97/002) managed by the General Department of Land Administration, the total length of required sea-dike walls in MRD would be 1469 kilometers. [Danh \(2012\)](#) and [Danh and Khai \(2014\)](#) argued

that Vietnam cannot afford to build the total required lengths of sea-dike walls due to public budget constraints. These authors go on to point out that, if these sea-dike walls were constructed, local authorities would also struggle to maintain them ([Danh, 2012](#)). This means that if any proposed intervention program based on infrastructure is to proceed and be sustained over time, local households may have to fill a construction and maintenance funding gap. However, it is unclear whether local households are willing to contribute to these types of public investments and, if so, how much they would be willing to contribute. The purpose of this paper is to explore MRD farm household willingness to contribute (pay) to local authority programs aimed at mitigating salinity intrusion risk.

The willingness to pay (WTP) literature is generally classified into revealed and stated preference methodologies; with stated preference methods typically employed to estimate WTP in contexts where actual markets for the good in question do not exist ([Bateman et al., 2002](#); [Competition Commission, 2010](#)). In climate change related research, a subset of stated preference estimations known as Contingent Valuation Methods (CVM) have been widely employed to estimate willingness to pay for climate risk reduction projects. Many of these previous climate risk reduction project studies have focused on issues such as willingness to pay for insurance ([Botzen et al., 2009](#); [Botzen and Van Den Bergh, 2008, 2012](#); [Charpentier, 2008](#); [McClelland et al., 1993](#)), flooding-risk mitigation through improved management ([Baan and Klijn, 2004](#); [Brilly and Polic, 2005](#)), and willingness to pay to reduce environmental health or mortality risks ([Alberini and Chiabai, 2007](#); [Alberini et al., 2006](#); [Corso et al., 2001](#)). However, while Southeast Asian countries also face emerging climate risks, previous studies of WTP have mainly been conducted in developed countries.

Moreover, studies looking at people's willingness to contribute to coastal defense in climate risk areas are quite rare. So far, research on this topic has only been conducted by [Jones et al. \(2015\)](#) in England and [Landry et al. \(2011\)](#) in the US; with little that can

be directly related to developing nation contexts. As a result, this paper contributes to significant gaps in the literature by applying a referendum contingent valuation methodology to evaluate developing country community contributions toward climate change risk reduction programs in the form of concrete sea-dike walls in the MRD.

This paper also attempts to identify the determinants of farm household characteristics on WTP. Previous studies have found a number of factors affecting people's WTP for climate change risk reduction in Japan, the Netherlands and Italy (Alberini and Chiabai, 2007; Botzen and van den Bergh, 2012; Zhai, 2006). For example, willingness to pay was positively associated with the size of the risk reduction (Alberini and Chiabai, 2007; Botzen and van den Bergh, 2012; Zhai, 2006), respondent age and health (Alberini and Chiabai, 2007), income (Zhai, 2006) and proximity to the risk (Concu, 2007). However, WTP can decrease with acceptability of (flood) risk and environmental information provision (Zhai, 2006). Moreover, risk awareness and geographical characteristics are also noted as important factors influencing respondents' willingness to pay (Botzen and Van Den Bergh, 2008). In those studies, referendum and payment cards were employed broadly as the instrument of CVM elicitation, and so we follow that approach in this paper.

2. Methods

Consistent with many of the studies of climate change risk reduction cited above, we employ the CVM approach to estimate farm household willingness to pay for MRD salinity intrusion management programs. CVM was first proposed by Ciriacy-Wantrup (1947), and since the 1970s the methodology has been routinely applied to measure the benefits of a variety of goods such as recreation, hunting, water quality and decreased mortality risk from accidents (Khai and Yabe, 2014). In essence, CVM requires each participant in a study to respond by employing four types of question including open-ended, dichotomous choice, iterative bidding or payment card. The most common question format is an open-ended and dichotomous choice. Although debate over the best form of CVM questionnaire continues, dichotomous choice rather than open-ended elicitation approaches are recommended due to minimization of opportunities for strategic behaviour, and an argument that such questions are cognitively easier on respondents (Mitchell and Carson, 1989). The valuation question in this study thus required each participant to respond to a dichotomous choice based on WTP guidelines by Bateman et al. (2002) and the Competition Commission (2010). The robustness of the decision to adopt a dichotomous choice format was enhanced in this instance by a large sample of farm households.

2.1. Survey method

The primary data for the study was obtained through a field survey conducted among farm households in the MRD. The questionnaire was pre-tested with 30 randomly-selected farm household heads spread across three MRD study areas ranging from heavily salinity-affected areas, down to non-salinity-affected areas. The purpose of the pre-test was to check likely farmer comprehension of the questionnaire, refine the range of willingness to pay bid measures proposed, and test the viability of the proposed payment vehicle; that is, the feasibility of getting farmers to make a monthly contribution to a fund managed by their local authority. Based on the pre-test results, five different bid values were chosen for the monthly payment vehicle: VND 50,000, 100,000, 150,000,

200,000 and 250,000 (equivalent to US\$¹ 2.20, \$4.41, \$6.61, \$8.81 and \$11.02).

Following the survey pretests and content finalization, the formal in-field face-to-face survey data collection commenced. The survey sample areas were based on an MRD salinity intrusion map provided by the local department of Agriculture and Rural Development. The opinion of local departmental staff as to which areas might present useful sample sites was also sought. As a result of this exercise, the survey was directed at three farmer groups: i) those where salinity intrusion impacts are already prevalent (the Cau Ke district); ii) those living in areas with a high probability and risk of future salinity intrusion (the Tra On district and part of the Cau Ke district); and iii) a control group-area where salinity intrusion is not yet of concern (the Vinh Thanh district in the Can Tho province). Using simple random sampling techniques, farm households were randomly selected from a list provided by district local authorities. Once selected, a survey enumerator² visited the household to ascertain eligibility for survey participation. To be selected, the head of the farm household or their partner had to live in the area, work on an MRD rice field, and have at least three years' farming experience. Eligible respondents were then asked some demographic and social characteristic questions. This was followed by questions related to their perceptions of local climate change, and then salinity impacts.³

Due to the importance of collecting reliable willingness to pay information, causes of salinity intrusion in the Mekong River Delta were first explained carefully to respondents. This included a range of hypothetical salinity reduction program options. Possible program options suggested in this survey included converting current earth sea-dike-walls to concrete structures, upgrading existing or building new river-mouth sluiceway systems, and the planting of new or reforestation of degraded existing mangrove systems next to sea-dike-walls. Each respondent was then asked whether or not they (their household) would be willing to contribute monthly to fund such programs. They were told that the program funds would be administered by a committee including their local government, local and international consultants, and representatives from non-government organizations. This committee would then decide how to invest in concrete sea-dike-walls, sluice-gate construction and mangrove forest in their local area. It was made clear that these programs would seek to reduce current and expected future salinity intrusion risk in their relevant village area.

Following the guidelines from Arrow et al. (1993) and Competition Commission (2010), willingness to pay bids were collected using a referendum style format where respondents could select one of three options: 'Yes', 'No', or 'Do not know' ('DK'). During the survey, respondents were given an opportunity to reconsider their vote before asking them to nominate their specific monthly payment bid. Each possible willingness to pay bid value was provided to at least 30 of the randomly selected farm households, for a total of 150 observations from each area. After data cleaning, there were 441⁴ useable observations from three different salinity-impact areas. Despite some disadvantages with referendum approaches, such as a limited range for the bid-values offered, this option simplifies the respondent's cognitive task (Pearce et al., 2002) which is an important factor in survey areas where farm

¹ US\$1 dollar was equal to 22,695 Vietnamese dong (VND) at May 01, 2017.

² Enumerators were carefully chosen from staff and final-year students from Department of Agricultural Economics, College of Economics at the Can Tho University. Those with previous experience of survey data collection and CVM approaches were specifically targeted. Each enumerator also received additional training before the official survey took place.

³ Sample copies of the questionnaire are available from the corresponding author in Vietnamese and English.

⁴ Sample size was identified by function: $n = z_{1-\alpha/2}^2 P(1-P)/d^2$.

household education levels can be quite low. Further, previous studies have identified the fact that CVM approaches can result in over-estimations of willingness to pay. The likelihood of this occurring can be reduced by: using survey pretesting ahead of official data collection, adopting face-to-face surveying approaches, and framing the willingness to pay question in the form of a referendum that includes a 'No vote' or 'Do not know' response option (Arrow et al., 1993; Carson et al., 1998; Competition Commission, 2010; Wang, 1997). In support of our adoption of these approaches, the referendum vote has been endorsed by the National Oceanic and Atmospheric Administration (U.S. NOAA) panel, which suggested that valuation questions should be formed as a vote, and include 'Do not know' answer options as distinct from 'Yes' and 'No' responses (Arrow et al., 1993; Carson et al., 1998; Champ et al., 2005; Pearce et al., 2002; Wang, 1997).

In this study, we also employed *ex-ante* bias correction by using a *cheap talk* instrument, which is designed to mitigate hypothetical bias by explaining the risk of this outcome to respondents before asking the valuation questions (Competition Commission, 2010; Mahieu et al., 2012). The version of the cheap talk approach we used was based on the 'short and neutral' approaches developed by Aadland and Caplan (2006), Do and Bennett (2007) and Khai and Yabe (2014). The cheap talk scrip was also tested to ensure good understanding by participants in the pilot survey. Our approach included a reminder to respondents to consider budget constraints when making their responses, and treating their decision as if the payment were real. This information is then cross-checked with information about the respondent's socio-economic characteristics and their ability to pay. Finally, an *ex-post* robustness approach was also adopted using a follow-up question asking respondents to specify the certainty of their answers (Champ et al., 1997; Competition Commission, 2010; Whitehead and Cherry, 2007). In these approaches, the farm household participants had more time to reconsider their responses before a firm decision was made and noted in the questionnaire.

2.2. Analytical method

The basic theory of CVM approach was proposed by Hanemann (1984), with concepts derived from consumer theory. We begin with the random utility function of a respondent, which is:

$$u_k = u_k(w, z, e_k) = v_k(w, z) + e_k \quad (1)$$

where $k=0$ is the status quo, and $k=1$ is the condition where a salinity intrusion mitigation public good is provided. Utility function components include income w , respondents' characteristics z , and error component e . Respondent's utility increases when public goods provided with the payment t_j are higher than utility in the status quo:

$$u_{1j} = u_1(w_j - t_j, z_j, e_{1j}) > u_0(w_j, z_j, e_{0j}) \quad (2)$$

The probability of an individual response would be 'yes' if the following conditions hold:

$$Pr(\text{yes}|t_j) = Pr(u_1(w_j - t_j, z_j, e_{1j}) > u_0(w_j, z_j, e_{0j})) \quad (3)$$

From Eq. (1), we can rewrite this probability as follows:

$$Pr(\text{yes}|t) = Pr(v_1(w_j - t_j, z_j) + e_{1j} > v_0(w_j, z_j) + e_{0j}) \quad (4)$$

and assume that the utility function v_k is linear. We can then rewrite Eq. (4) as:

$$Pr(\text{yes}|t) = Pr(\alpha_1 z_j + \beta_1(w_j - t_j) + e_{1j} > \alpha_0 z_j + \beta_0 w_j + e_{0j}) \quad (5)$$

This then allows us to rearrange the above function as follows:

$$Pr(\text{yes}|t) = Pr((\alpha_1 - \alpha_0)z_j - \beta t_j + e_{1j} - e_{0j} > 0) = Pr(\alpha z_j - \beta t_j + e_j > 0) \quad (6)$$

Where $\alpha = \alpha_1 - \alpha_0$, and $e_j = e_{1j} - e_{0j}$. Because the error terms are assumed to be independently and identically distributed, the probability of a respondent choosing 'yes' can be estimated with:

$$Pr(\text{yes}|t_j) = Pr(\alpha z_j - \beta t_j + e_j > 0) = Pr(e_j > -(\alpha z_j - \beta t_j)) = Pr(e_j < (\alpha z_j - \beta t_j)) = F(\alpha z_j - \beta t_j) \quad (7)$$

The function in Eq. (7) is then estimated using maximum likelihood procedures, and v assumes a linear form including income w , farm household's characteristics z and the final bid value. In this study, Multinomial Logistic Regression (MNL) and Binary Logistic Regression treatment models were initially employed to analyse the referendum format of the CVM. Details of such analysis models are discussed by Lancsar et al. (2017).

As stated above, in our CVM survey farm households were asked to respond to the willingness to pay bid value question in one of three ways: 'Yes,' 'No' or 'Do not know'. In the analysis model α and β are coefficients, and X is a vector of the socio-economic explanatory variables related to an individual's selection including: farm household income, head of household's age, head of household's gender, farm household size, head of household's education and total farming experience (Table 1). The non-parametric technique is employed to estimate the mean values for WTP. This technique was suggested by previous researchers in the same survey area (Dan and Duyen, 2010; Khai and Yabe, 2014). Thus, we estimated mean willingness to pay values as follows:

$$n_j = \sum_{k=j+1}^5 N_k \quad (8)$$

where N is the sample size, N_j is the sub-sample size who chose B_j (with B_j as the bid value where $j = 1, 2, 3, \dots, N$), and n_j is the sub-sample size that is willing to pay more than bid value B_j . Then, the survivor function at each B_j is:

$$S(B_j) = \frac{n_j}{N} \quad (j = 0 \text{ to } 5) \quad (9)$$

Finally, the mean value for MRD farm households' willingness to pay is estimated as follows:

$$\text{Mean WTP} = \sum_{j=0}^5 S(B_j)(B_{j+1} - B_j) \quad (10)$$

3. Results

3.1. Descriptive analysis results

The socioeconomic characteristics for each of the MRD farm household groups are presented in Table 2 below. To test for sample representativeness, the results are compared with data from the Vietnam Household Living Standard Survey (VHLSS) – a national survey of the Vietnamese population conducted every two years. In general, respondent characteristics in each group are consistent across the three groups, and with the VHLSS results. In the context of an MRD culture in which decision makers are typically men, the majority of household heads interviewed were male. The average age of the head of household was 47 years. The mean head of household's education level was 2.05 for the current salinity-impacted group, 2.03 for the high future risk group, and 2.48 for the control group; indicating that MRD farmers have mainly achieved primary or secondary school-level educations. The majority were born

⁵ Vietnam Household Living Standard Survey 2010. There is a wider range of educational levels (1: Primary school, 2: Secondary school, 3: High school, 4–7: Vocational education, 8: College, 9: University, 10: Masters, 11: PhD, 12: other) used in the VHLSS, and this difference is taken into account in our comparison.

Table 1
Summary statistics for the model variables.

Variable	Description	Mean	Min.	Max.	Standard deviation
Bid value	Vietnamese dong (1000 VND)	150.453	50	250	70.789
Farm household income	Total income per year (1000 VND)	107,594.8	7500	711,100	102,445.3
Head of household's age	Years	47.410	24	81	9.926
Head of household's gender	0: Male, 1: Female	0.172	0	1	0.378
Household size	Number of people in household	4.285	1	10	1.274
Head of household's education	0 = never attended school, 1 = primary school, 2 = secondary school, 3 = high school, 4 = bachelor degree and 5 = post-graduate degree	2.190	0	5	1.146
Farming experience	Years	23.399	1	65	10.915

Table 2
Socio-economic characteristic comparisons between this survey and the Vietnam Household Living Standard Survey (VHLSS).

Variables	Mean value in VHLSS ⁵	Mean study survey values		
		Group 1 With SI	Group 2 High-risk SI	Group 3 No risk SI
Age	49.52 (14.15)	46.89 (10.09)	46.46 (9.81)	48.83 (9.77)
Gender	0.27 (0.44)	0.20 (0.40)	0.23 (0.42)	0.10 (0.29)
Education	1.29 (1.89)	2.05 (1.17)	2.03 (1.14)	2.48 (1.08)
Farming experience	N/A	23.38 (12.04)	22.41 (11.21)	24.37 (9.35)
Household size	2.15 (1.29)	4.31 (1.12)	4.41 (1.23)	4.15 (1.43)
Farm household income	64,900.00 (62,100.00)	106,564.30 (110,675.90)	103,977.80 (118,674.40)	112,094.30 (73,665.07)

Numbers in parentheses denote standard deviation values. For variable descriptions of the study, see Table 1. SI: salinity intrusion.

immediately after the Vietnam war when much of the national and local infrastructure had been destroyed, and communities were trying to re-establish themselves. This may explain the relatively low education levels among respondents. In terms of farm household income, the control group (Group 3) had highest annual income at VND 112 million per annum (US\$5022); compared to the salinity intrusion (Group 1) and high-risk groups (Group 2) which on average earned VND 104.5 million per annum (US\$4753). This outcome, together with the higher variability in results as depicted by the standard deviation values, would suggest some negative farm income affects associated with current salinity and/or the risk of future salinity impacts.

In addition, to identify any differences in the mean values of the variables in Table 2 across the three farm households groups, we employed the one-way analysis of variance (ANOVA) and Tukey *post-hoc* tests. The ANOVA results confirmed no statistically significant differences between the three groups, except gender ($F(2438) = 5.28$, $p = 0.0054$) and education level ($F(2438) = 7.13$, $p = 0.0009$). Similarly, the Tukey *post-hoc* test revealed slightly higher farm head of household education levels in the control group (Group 3), and slightly higher numbers of females in Groups 1 and 2. However, the differences are minimal and we therefore conclude that the analysis results from this study are broadly representative of the MRD farmer population.

3.2. Willingness to pay results

3.2.1. Reasons for unwillingness to pay

In terms of respondents' willingness to pay our study first examined reasons why respondents may be unwilling to pay for the goods of interest. Key reasons offered include a preference for alternative goods and programs, a lack of capacity to pay, and questions of government capacity to manage the proposed program(s).

Table 3 summarises the reasons why some farm households are unwilling to contribute to the proposed salinity reduction program. The main reason households voted against a proposed program was their reported inability to afford the required payments. The second highest selected reason was a farm household perception that salinity intrusion reduction should primarily be the responsibility of the Vietnamese government. Approximately 20 percent of farm households also did not believe that their contributions would be used to fund the program correctly. Finally, approximately 15 percent of farm households in salinity-impacted areas voted against the program contributions because they felt that they could adapt to, and live with, MRD salinity intrusion.⁶

3.2.2. Willingness to pay and its determinants

Fig. 2 summarizes the proportion of farm household responses to various bid levels offered in the survey. In general, the percentage of farm households answering 'Yes' decreases as the bid level increases. However, those MRD farms that are currently affected by salinity or facing a high risk of future impact were generally inclined toward a 'Yes' response; even at higher bid levels.

As expected, the proportion of farmers that indicated their unwillingness to contribute increased as bid levels were raised, but again with smaller total percentages from the currently-affected and high future risk groups. Finally, the proportion of farmers answering 'Do not know' to the bid levels rapidly falls to zero in the control group but remains positive for the other groups at rela-

⁶ Following discussion by Jorgensen et al. (1999), we estimated the Model results using expanded zero-bid protest vote definitions that included program ineffectiveness beliefs and feelings that the respondent can deal with problem by themselves. The model estimates did not vary greatly from the original analyses, and so were not included here. These estimates are available on request.

Table 3
Reasons for voting against salinity reduction contributions in the MRD.

Reasons	Group 1 With SI		Group 2 High-risk SI		Group 3 No risk SI	
	Number	%	Number	%	Number	%
I cannot afford that amount	31	49.21	27	33.75	40	38.83
I do not think the upgrading of dike-walls is worth doing	0	0	0	0	1	0.97
I do not think that amount I would pay will be actually used for this program	5	7.94	20	25.00	19	18.45
I think this is the responsibility of the government	16	25.40	31	38.75	39	37.86
I think other adaptation measures are more efficient than this program	0	0	0	0	0	0
I can deal with this using my own adaptation options	9	14.29	0	0	0	0
Other	2	3.17	2	2.50	4	3.88
Total	63	100	80	100	103	100

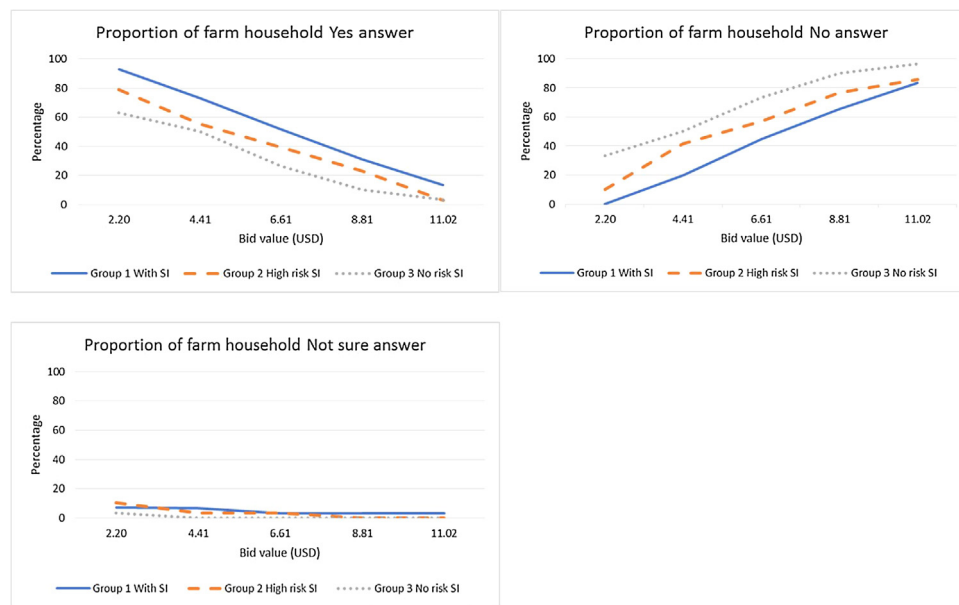


Fig. 2. Proportion of farm household answers to each bid option.

tively low levels (~4% on average). These results suggest that MRD farmers recognize the significant risks and negative impacts associated with salinity intrusion, even when they are not yet exposed to salinity.

Factors that influence MRD farm households' willingness to pay for salinity intrusion risk reduction are presented in Table 4. We estimate the results across three models: Model 1 is an MNL model with 'No' responses as the base-outcome, while Model 2 is a Binary Logistic Regression that reclassifies all 'Do not know' answers as a 'No'. In Model 3, also in the form of a Binary Logistic Regression, 'Do not know' answers are deleted entirely from the dataset.

The results of model fit statistics showed that the likelihood ratio (LR) in three models are significant: $p < 0.001$ in all Models, and Pseudo R-square values of 0.304, 0.294 and 0.338 in Models 1, 2 and 3 respectively. Hence, this result indicated a good fit, and all three Models are statistically significant and explained by the independent variables included. Further, and as detailed in Table 4, Variance Inflation Factor (VIF) values for each of the independent variables are smaller than 7.0, indicating that there are no significant multicollinearity issues with the modeling.

The results from the three models are broadly uniform. Consistent with economic theory, farm household income and bid value

are strongly correlated with increased probability of willingness to pay; that is, high farm income correlates with a positive probability of willingness to pay. As expected, higher bid values are negatively correlated with a probability of willingness to pay in a manner that is consistent with other climate change impact studies (e.g. Wang, 1997) and willingness to pay studies from the MRD (Đan and Duyệt, 2010; Khai and Yabe, 2014).

Interestingly, although older farmers are weakly associated with an increased probability of willingness to pay, farmers with more experience were generally less likely to be willing to pay toward salinity intrusion reduction programs. We did not expect to find this outcome; it may be because experienced MRD farmers feel capable of dealing with salinity intrusion on their own, or consider that local authorities cannot be trusted to manage the problem effectively. In any case, this result is supported by recent research on farmers' willingness to pay for rice farming insurance in the MRD (Thong, 2014). Finally, the negative coefficient for the group variable suggests that the probability of farm household willingness to pay increases with their proximity to current and expected salinity impact.

Results from the non-parametric estimation methods using Eq. (10) show that the highest willingness to pay level is associ-

Table 4
Marginal effects of stated willingness to pay for salinity intrusion risk reduction.

Variables	Model 1 MNL approach 0 = No (base outcome), 1 = DK, 2 = Yes			Model 2 Binary Logistic Regression 0 = No/DK, 1 = Yes	Model 3 Binary Logistic Regression (DK deleted) 0 = No, 1 = Yes	VIF
	0	1	2			
Bid value	0.003*** (0.001)	-0.001** (0.001)	-0.003*** (0.001)	-0.004*** (0.001)	-0.005*** (0.001)	1.02
Age	-0.007*** (0.003)	0.001 (0.001)	0.006* (0.003)	0.008* (0.005)	0.010** (0.005)	3.01
Gender	0.017 (0.052)	0.021 (0.019)	-0.039 (0.053)	-0.074 (0.074)	-0.057 (0.081)	1.10
Education	0.016 (0.017)	-0.003 (0.008)	-0.013 (0.017)	-0.020 (0.026)	-0.025 (0.027)	1.13
Farming experience	0.011*** (0.003)	-0.001 (0.001)	-0.009*** (0.003)	-0.014*** (0.005)	-0.017*** (0.005)	3.07
Household size	-0.005 (0.015)	0.006 (0.006)	-0.001 (0.015)	-0.001 (0.022)	0.007 (0.024)	1.05
Farm household income	-7.60e-07*** (1.90e-07)	-1.29e-07 (1.30e-07)	8.89e-07*** (1.99e-07)	1.30e-06*** (0.000)	1.34e-06*** (0.000)	1.07
Group	0.124*** (0.022)	-0.019 (0.012)	-0.105*** (0.023)	-0.160*** (0.037)	-0.191*** (0.039)	1.05
Log-Likelihood		-244.8378		-211.13328	-193.16083	
Pseudo R-square		0.3036		0.2937	0.3382	
Prob > chi2		0.0000		0.0000	0.0000	
N (sample size)		441		441	428	

***, ** and * indicate to statistically significant at 1%, 5% and 10% levels, respectively; Standard errors of marginal effects (dy/dx) are in parentheses.

ated with the group already experiencing high salinity intrusion (Table 5). Farm households in this group are willing to contribute approximately US\$2.58 per month toward the salinity reduction programs, while farms in the control group are only willing to contribute around half of that amount; i.e. US\$1.32 per month. Across the three groups, annual farm household contribution to salinity reduction programs would average US\$23.57. A Kruskal-Willis H test was employed to examine whether these WTP values were statistically different for the three farm household groups. The results showed a statistical difference between the three groups ($\chi^2(2)=9.847$) at a strong significance level ($p=0.0073$), which is below 0.01.

We can loosely compare this to research in the UK, where people were willing to pay a monthly premium of £4.46 (about US\$5.77) for coastal defence projects (Jones et al., 2015). This finding is also somewhat comparable with a review of previous studies which indicated that annual willingness to pay for climate policy is in a range of between US\$22 and US\$437 per household in samples drawn from American, Asian and European populations (Johnson et al., 2010). Finally, in the literature surrounding climate change mitigation projects funded by higher energy prices, we note that Korean consumers are willing to pay US\$3.21 per month for renewable energy (Lee and Heo, 2016), while Japanese consumers' median WTP for green electricity is about US\$17 per month (Nomura and Akai, 2004); which align with the values reported here. In any case, the results of this study reveal a promising community participation attitude toward solving the sea-dike public funding deficit in Vietnam, offering a promising basis for policy-makers to establish appropriate projects/actions.

3.2.3. Adjustment for biases

Finally, our study also estimated relative economic sacrifice (RES) values to assess the robustness of the willingness to pay results, where $RES = B_i/Y_i$, B_i is the chosen bid level, and Y_i is the farm household's total income. This RES is the ratio between the respondent's willingness to pay level and total per annum farm household income. The RES value for each farm household group was 0.0032 (salinity-impacted areas), 0.0034 (high future risk areas) and 0.0019 (control group areas). These values are relatively small and suggest that our willingness to pay estimates are not overstated. This conclusion is further supported by an assessment of the ratio between mean willingness to pay and annual farm household income.

4. Discussion

The positive willingness to pay results reported here suggest that MRD farm households are concerned about the adverse impacts of salinity intrusion. While some larger MRD farm households may struggle to contribute, as reflected in our findings, there is little evidence of a large-scale protest. Based on our results, it is reasonable to conclude that the financial impact on most households would be minimal; approximately at the 0.65 of one percent level of annual net farm income. The next issue to consider is the question of how much money might be needed to fund an effective salinity intrusion control program, and how much households could contribute to the cost of running such a program. As shown in Fig. 3, and according to Danh (2012), one option is to build around 1469 km of concrete sea-dikes. Accepting this as a possible scenario, and noting that:

- it may be possible for many farmers to live with and adapt to salinity intrusion by doing such things as moving from rice production to fish or shrimp farming;

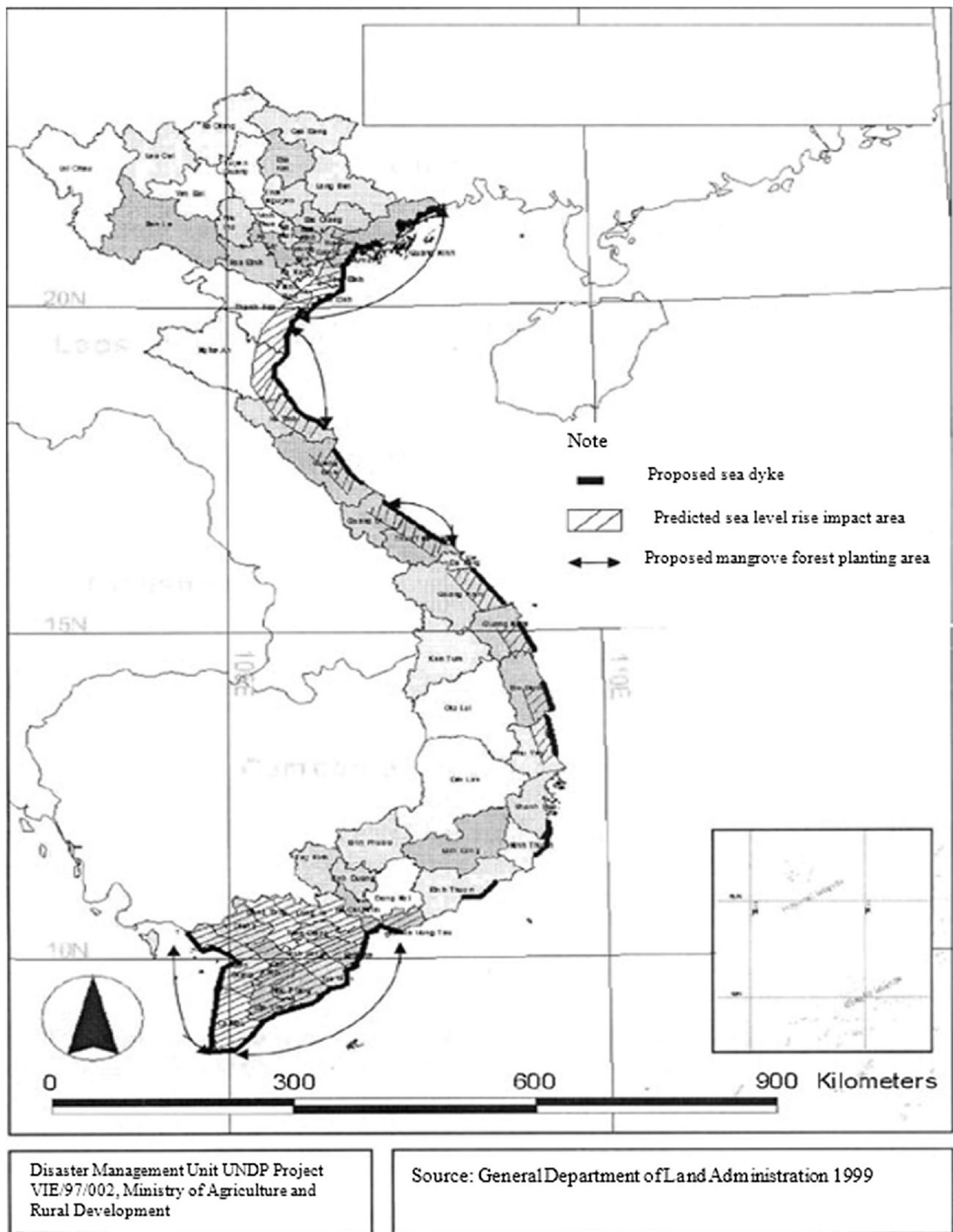


Fig. 3. Sea-dike map in Vietnam.

Table 5
Mean of WTP by impact group.

	Group 1 With SI	Group 2 High-risk SI	Group 3 No risk SI
Mean WTP per month (USD)	2.58 (58,562VND)	1.99 (45,172VND)	1.32 (30,000VND)
WTP annum (USD)	30.96	23.88	15.86
Proportion of WTP per total household income annum	0.65%	0.52%	0.32%

Source: Computed by authors and adapted from [Danh \(2012\)](#).

Table 6
Total estimated sea-dike-wall construction costs, under three wall height scenarios.

	Height at 2 m	Height at 3 m	Height at 4 m
Total dike-wall construction costs (in millions of US\$ per km) in rural Vietnam	\$1.16m	\$1.93m	\$2.79m
Total cost (for 1469 km concrete sea-dikes)	\$1,700m	\$2,833m	\$4,107m
Annual payment required to service a 40 year ADB loan sufficient to build the sea-dikes ⁸ (interest rate at 1.08 percent per annum)	\$52.56 m	\$87.60 m	\$126.99 m
Required annual contribution per household to repay the ADB loan	\$15.93	\$26.54	\$38.48

- b) that a combination of earth dikes and mangroves may provide a more environmentally-friendly program and, after a completion of a full economic evaluation of non-market benefits, may also provide a more socially beneficial solution; and
- c) under the premise that some of this problem has been caused by the actions of people in other countries and that, as such, a significant international contribution to the cost of controlling salinity intrusion could be expected

it may be possible to conduct a more detail exploratory analysis of the feasibility of calling upon MRD households to fund much, if not all, of any MRD salinity intrusion control program.

[Table 6](#) contains estimates of the costs of constructing and maintaining concrete sea-dike-walls across rural Vietnam, adapted from [Danh \(2012\)](#). A two-meter concrete sea-dike-wall requires approximately US\$1.16 million per kilometre in construction costs. This increases to US\$2.8 million per kilometre if the sea-dike-wall height is increased to four meters. Over the total length of MRD coastal area identified, program costs for concrete sea-dike-wall construction would require total funding of approximately US\$1.7 billion for two-meter concrete sea-dike-walls; US\$2.8 billion for three-meter concrete sea-dike-walls; and US\$4.1 billion for four-meter concrete sea-dike-walls. Significantly, as a relatively poor country and where climate-induced sea level rise is the prime cause of the salinity intrusion problem, the Vietnamese Government should be able to borrow the money needed to build a sea-dike-walls system at 1.08%⁷ p.a. interest rate from Asian Development Bank (ADB), and repay the principle over a loan term 40 years. If this is the case, then the annual payment would be between \$53 m and \$127 m per annum ([Table 6](#)).

If the repayment figure is then equally divided across the 3.3 million farm households⁹ currently located in the MRD ([Ministry of Planning and Investment, 2015](#)), it would result in a need to

collect between US\$16 and US\$39 per farm household. However, if the contribution involves all households (including non-farm households) in the MRD, where a total of 4.7 million households are located, the annual payment period will be decreased from 40 to 30 years, and the annual contribution required per household would fall to between US\$14 and US\$35 per household. Clearly, this is a very crude estimate, and not sufficient to recommend the implementation of an MRD concrete sea-dike program. Nevertheless, the estimated per farm household contribution required to meet ADB loan repayment is less than the average stated willingness to pay levels found in our study. Therefore, our results suggest that in the absence of other public funds, private MRD farm household contributions may be sufficient to cover the cost of building a concrete sea-dike that would protect farm lands from climate change-induced sea level rise. The issue of whether this is equitable remains the subject of further analysis and discussion that we will address in future research. Nevertheless, the insights provided by this paper have important ramifications for Vietnam, other developing country contexts faced with salinity intrusion impacts, and broader climate change management policy.

5. Conclusions

This study estimates MRD farm household willingness to pay for salinity intrusion mitigation programs. The results reveal that more than 50 percent of farm households are willing to contribute to a fund that could be used to reduce salinity intrusion risk, and that their willingness to pay is in proportion to expected salinity impacts. Farm households in current salinity intrusion-affected areas are more willing to pay for risk reduction programs than those farm households located in lower or no-current risk areas. However, all farm households included in the study—including those who at present are unaffected by salinity intrusion—are willing to pay for an MRD salinity management program.

When assessed in aggregate, the total amount of money that farm households are prepared to pay is significant, and may be sufficient to cover the total costs of such a program. Care must be taken, however in the interpretation of this result. While the payment vehicle adopted in this study suggests feasibility, work on the most appropriate government arrangements requires further analysis. Careful research, for example, on the merits of establishing a separate salinity intrusion control authority versus the use

⁷ This is the Weighted Average Cost of Capital (WACC) estimated by Asian Development Bank applied for Transport Corridor - Noi Bai - Lao Cai Highway Project loan for Vietnam.

⁸ Identified by function $A = US\$loan\_amount [i(1+i)^n] / [(1+i)^n - 1]$ where i is WACC and, n is number of loan years.

⁹ The number of household in MRD is around 4.7 million in 2015 (The Vietnam General Statistic Office - www.gso.gov.vn), in which 69.3% are farm household in rural areas (Ministry of Planning and Investment).

of an existing government structure is needed. Similarly, there is a need to consider how best to involve farmers in any program that they pay for. Further, the question of whether or not MRD farm households should be made to pay for the adverse effects of global climate change and upstream development is an important ethical and legal question to resolve. It is our intention to address these issues in future research papers.

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